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SEMICONDUCTOR SINGLE CRYSTAL MANUFACTURING APPARATUS

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Claim

A semiconductor single crystal manufacturing apparatus characterized by the fact that, in the semiconductor single crystal manufacturing apparatus for carrying out the crystal pull-up from the upper layer of the semiconductor base material melt stored in a melt tank, a heating apparatus for maintaining the upper layer of the melt mentioned previously at the highest temperature is provided so that it virtually contacts the liquid surface of the melt mentioned previously in virtually the entire range of this liquid surface or it is slightly dipped in the liquid and, at the same time, the side sections and the bottom section of the melt tank have an adiabatic structure.

Detailed explanation of the invention

Industrial application field

The present invention relates to a semiconductor single crystal manufacturing apparatus for carrying out the crystal pull-up from the upper layer of the semiconductor base material melt stored in a melt tank.

Prior art

In general, the manufacturing apparatus of this type, for example, a manufacturing apparatus for single crystals of the semiconductor of, for example, GaAs or other compounds, has a gas-tight vessel (11), as shown in Figure 2. Inside this vessel (11), the melt tank (12) is provided. On the outside wall, the electric heater (22) is provided for melting the semiconductor base material filled in the tank (12) into the melt (the semiconductor base material melt) (21). The melt (21) is stored in the bottom section of the tank (12). On top of it, the cover liquid (23) for the prevention of gasification of the melt (21) is stored.

The apparatus in Figure 2 further has rotary shafts (24) and (25). The rotary shaft (24) penetrates the bottom of the vessel (11) via the shaft seal mechanism (26) and its top end is fixed at the bottom of the melt tank (12). Furthermore, the rotary shaft (the pull-up shaft) (25) penetrates the top of the vessel (11) via the shaft seal mechanism (27). This rotary shaft (25), in a state in which the solidification-adhered semiconductor crystals (28) are connected to its lower

end and the tip of the same crystals (28) is contacted with the central portion of the liquid surface (29) of the melt (21), is rotated while it is moved upward at a low speed. As a result, from the liquid surface (29) of the melt (21), the melt (21) is pulled up slowly, cooled and crystallized.

Problems to be solved by the invention

In the semiconductor crystals (28) manufactured with the single crystal manufacturing apparatus in Figure 2, the striped texture can be observed to some extent. This stripe is a concentration unevenness caused by an impurity or the like. Therefore, the semiconductor crystals (28) having the striped texture of this kind have a problem in the aspect of electrical uniformity. The present inventors have recognized that the formation of the striped texture mentioned previously is caused by unevenness or fluctuation in the liquid temperature in the upper layer portion of the melt (21) due to convection (provided for the crystal growth) inside the melt tank (12). Furthermore, the present inventors have also recognized that the occurrence of convection mentioned previously is caused by the temperature distribution of the melt (21). In other words, in the apparatus of Figure 2, the temperature of the melt (21) is high in the vicinity of the sidewall of the melt tank (12). Therefore, the melt (21) (in the vicinity of the sidewall of the melt tank (12)) heated with the electric heater (22) will rise along the internal sidewall of the melt tank (12). The rising stream along the internal sidewall of the melt tank (12) then moves in the radial direction toward the center axis (30) of the melt tank (12) in the upper layer portion of the melt (21). This stream in the radial direction becomes a descending stream in the vicinity of the center axis (30). As a result, inside the melt tank (12), convection occurs in the manner shown by the dashed line in Figure 2.

Thus, in the present invention, the task is to prevent the occurrence of convection caused by the formation of a localized high-temperature portion of the semiconductor base material melt in the vicinity of the sidewall of the melt tank and to enable to manufacture the semiconductor single crystals with a good electrical uniformity.

Means to solve the problems

The present invention is one in which a heating apparatus for maintaining the upper layer portion of the semiconductor base material melt stored in a melt tank at the highest temperature is provided so that it virtually contacts the liquid surface of the melt mentioned previously in virtually the entire range of this liquid surface or it is slightly dipped into the liquid and, at the same time, the side sections and the bottom section of the melt tank mentioned previously have an adiabatic structure.

Operation

With the adiabatic structure and the heating apparatus described previously, the high temperature of the melt in the vicinity of the sidewall of the melt tank can be prevented and the convection can be prevented. Furthermore, since the upper layer of the melt is maintained at the highest temperature by the heating apparatus, for example, even if convection occurs in the lower portion of the melt, there is no movement in the upper layer of the melt to be supplied to the crystal growth. A better uniformity in the temperature of the upper layer of the melt can be achieved.

Application example

Figure 1 shows a semiconductor single crystal manufacturing apparatus related to an application example of the present invention. (41) is a gas-tight vessel. The pressure inside the vessel (41) is maintained at a few tens of kg/cm^2 g or so. Inside the vessel (41), the melt tank (42) of a circular cylindrical shape having a bottom is provided. Inside the melt tank (42), the partition wall (43) of a circular cylindrical shape having a bottom with a smaller diameter than the top end portion is provided. The top end rim of this partition wall (43) is fixed on the internal sidewall of the central portion of the melt tank (42). The space enclosed by the melt tank (42) and the partition wall (43) communicates with a vacuum pump not shown in the diagram via the piping (44) penetrating through the vessel (41). By being maintained in a vacuum state by vacuum suction with said pump, the adiabatic section (45) is formed. By charging an adiabatic component excellent in thermal adiabatic characteristics in this space, the adiabatic section (45) can also be formed. In the adiabatic section (45), the electric heater (52) for melting the semiconductor base material charged inside the melt tank (42) at a high temperature to yield the melt (the semiconductor base material melt) (51) is provided so that the partition wall (43) is surrounded. The melt (51) is stored in the lower portion of the melt tank (42). On top of it, the cover liquid (53), such as a low-melting-point glass liquid or the like for the prevention of the gasification of the melt (51) is stored.

(54) and (55) are rotary shafts. The rotary shaft (54) penetrates the bottom of the vessel (41) via the shaft seal mechanism (56) and its top end is fixed at the bottom of the melt tank (42). The bottom end is coupled to a rotary shaft driving mechanism not shown in the diagram. On the other hand, the rotary shaft (55) penetrates the top of the vessel (41) via the shaft seal mechanism (57). Its top end is coupled to a rotary shaft driving mechanism not shown in the diagram. This rotary shaft (55) is used as a pull-up shaft for pulling up the semiconductor crystals (58), grown at its bottom end, from the liquid surface (59) of the melt (51).

(60) is the liquid surface heating apparatus provided for maintaining the temperature of the upper layer of the melt (51) in a uniform manner and at the highest temperature so that it

covers virtually the entire range of the liquid surface (59) (excluding the central portion supplied for the growth of the semiconductor crystals (58)) of the melt (51). The liquid surface heating apparatus (60) has the annular electric heater block (61) and the annular temperature equilibrium block (62) adhered to the bottom side of this electric heater block (61). This temperature equilibrium block (62) has, for example, a two-layer structure consisting of a copper plate excellent in thermal conductivity as the top layer and a heat-resistant plate of the same material as the melt tank (42) as the bottom layer. The liquid surface heating apparatus (60) further has the annular heat-shielding block (63) surrounding the semiconductor crystals (58). This heat-shielding block (63) prevents the unnecessary heating of the semiconductor crystals (58) by the electric heater block (61). It is made of an adiabatic material. Its lower external sidewall is fixed on the internal sidewall of the electric heater block (61).

In this application example, the temperature equilibrium block (62) is virtually contacted with the liquid surface (59) of the melt (51). It is also acceptable that the block be slightly dipped in the melt (51). However, since the liquid surface (59) of the melt (51) drops with a decrease in the liquid amount of the melt (51) due to the growth of the semiconductor crystals (58), it is necessary that the liquid surface heating apparatus (60) have a structure capable of moving by following the descending of the liquid surface of the melt (51). For this purpose, for example, it has a structure capable of moving the liquid surface heating apparatus (60) up or down. A means for controlling its moving amount by programming or in accordance with the detection of the position of the liquid surface (59), or a relatively simple means using the liquid surface heating apparatus (60) as the self-flotation structure or the like can be used appropriately. Since the means of this type capable of moving by following the surface dropping is well known, the detailed explanation will be omitted.

Next, the actions of the constitution of Figure 1 will be explained. First of all, after a desired semiconductor base material has been filled into the melt tank (42), by electrifying to the electric heater (52) to heat the inside of the melt tank (42) to a high temperature, the semiconductor base material is melted to yield the melt (51) to a virtually specified temperature. Afterwards, the electricity to the electric heater (52) is stopped. By the vacuum suction of the space enclosed by the melt tank (42) and the partition wall (43) to a vacuum state via the pipe (44) with a vacuum pump not shown in the diagram, the adiabatic section (45) is formed. In doing so, an increase in the temperature of the melt (51) in the vicinity of the sidewall of the melt tank (42) can be prevented. On the other hand, the electric heater block (61) of the liquid surface heating apparatus (60) is started and the upper layer portion of the melt (51) is maintained at the specified temperature with a good accuracy. Afterwards, in this state, by the rotation of the rotary shaft (55) as it is being moved upward at a low speed, the semiconductor crystals (58) are pulled up from the upper layer portion of the melt (51) and allowed to grow.

In regard to the temperature distribution of the melt (51) inside the melt tank (42) while the crystals (58) are being pulled up, the upper layer portion is maintained at the highest temperature because of the heating action due to (the electric heater block (61) of) the liquid surface heating apparatus (60). The middle layer portion and the lower layer portion are about the same, or the lower layer portion is somewhat lower in temperature. Furthermore, the temperature distribution in each layer is virtually constant. Therefore, the convection of the melt (51) inside the melt tank (42) virtually does not occur. For example, even if it occurs, it is very weak. Furthermore, in this application example, since the upper layer portion of the melt (51) is maintained at the highest temperature in the manner described previously, even if the convection occurs in the lower layer of the melt (51), there is no movement of the melt (51) in the upper layer portion. There is no possibility of having the lower layer portion convection on the semiconductor crystal growth in the center of the upper layer portion of the melt (51). In doing so, according to the present application example, the occurrence of convection over the entire liquid layer as shown by the dashed line in Figure 2 can be prevented. Semiconductor crystals (58) with good electrical uniformity free from the striped texture can be manufactured.

Furthermore, in this application example, since the liquid surface heating apparatus (60) is contacted with the liquid surface (59) of the melt (51), there is no fluid interface between the liquid surface (59) and the cover liquid (53). The occurrence of the convection phenomenon caused by the surface tension in the upper layer portion of the melt (51) is prevented. Moreover, in this application example, further uniformity in the temperature of the upper layer portion of the melt (51) is to be achieved by the temperature equilibrium block (62) at the bottom of the liquid surface heating apparatus (60). In the manner described previously, the electrical uniformity of the semiconductor crystals (58) can be further improved. In the present invention, with the prevention of the occurrence of convection over the entire melt as the main gist, the temperature equilibrium block (62) is not necessarily required. Furthermore, since the liquid surface heating apparatus (60) is provided to maintain the upper layer portion of the melt (51) at the highest temperature, it can also be simply provided adjacent to the liquid surface (59).

Effect of the invention

According to the present invention, the increase in the temperature of the semiconductor base material melt in the vicinity of the sidewall of the melt tank is prevented in order to achieve uniformity in the temperature distribution and to maintain the temperature of the upper layer portion of the melt at the highest temperature. Thus, the occurrence of convection over the entire melt can be prevented, and semiconductor crystals free from the striped texture and good in electrical uniformity can be manufactured.

Brief description of the figures

Figure 1 is a diagram showing an application example of the semiconductor single crystal manufacturing apparatus of the present invention. Figure 2 is a diagram showing the conventional semiconductor single crystal manufacturing apparatus.

42 ... Melt tank, 43 ... Partition wall, 45 ... Adiabatic section, 51 ... Melt (Semiconductor base material melt), 52 ... Electric heater, 54, 55 ... Rotary shafts, 58 ... Semiconductor crystals, 60 ... Liquid surface heating apparatus, 61 ... Electric heater block, 62 ... Temperature equilibrium block, 63 ... Heat-shielding block.

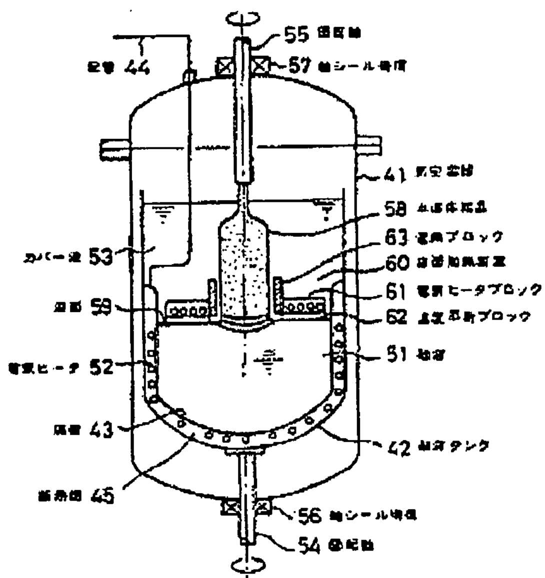

Figure 1

Key:	41	Gas-tight vessel
	42	Melt tank
	43	Partition wall
	44	Pipe
	45	Adiabatic section
	51	Melt
	52	Electric heater
	53	Cover liquid
	54	Rotary shaft
	55	Rotary shaft
	56	Shaft seal mechanism
	57	Shaft seal mechanism
	58	Semiconductor crystals

59 Liquid surface
60 Liquid surface heating apparatus
61 Electric heater block
62 Temperature equilibrium block
63 Heat-shielding block

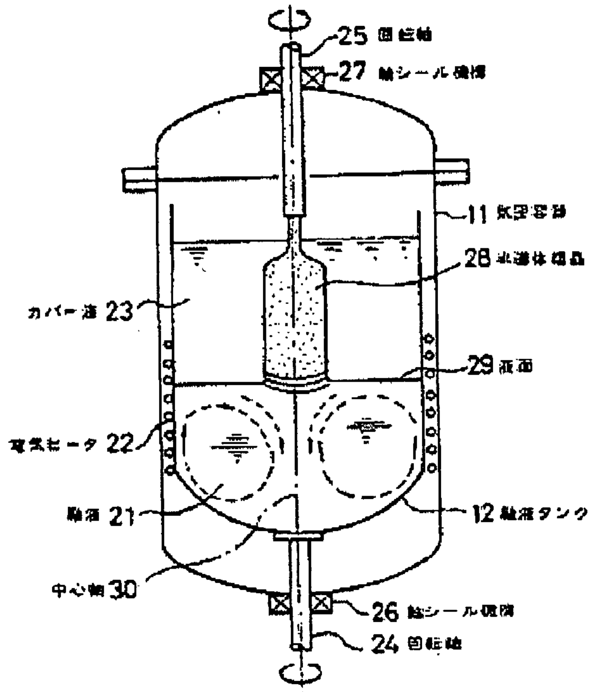

Figure 2

Key:
11 Gas-tight vessel
12 Melt tank
21 Melt
22 Electric heater
23 Cover liquid
24 Rotary shaft
25 Rotary shaft
26 Shaft seal mechanism
27 Shaft seal mechanism
28 Semiconductor crystals
29 Liquid surface
30 Center shaft